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Review

Vibroacoustic disease: Biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling

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Abstract

At present, infrasound (0–20 Hz) and low-frequency noise (20–500 Hz) (ILFN, 0–500 Hz) are agents of disease that go unchecked. Vibroacoustic disease (VAD) is a whole-body pathology that develops in individuals excessively exposed to ILFN. VAD has been diagnosed within several professional groups employed within the aeronautical industry, and in other heavy industries. However, given the ubiquitous nature of ILFN and the absence of legislation concerning ILFN, VAD is increasingly being diagnosed among members of the general population, including children. VAD is associated with the abnormal growth of extra-cellular matrices (collagen and elastin), in the absence of an inflammatory process. In VAD, the end-product of collagen and elastin growth is reinforcement of structural integrity. This is seen in blood vessels, cardiac structures, trachea, lung, and kidney of both VAD patients and ILFN-exposed animals. VAD is, essentially, a mechanotransduction disease. Inter- and intra-cellular communication is achieved through both biochemical and mechanotranduction signalling. When the structural components of tissue are altered, as is seen in ILFN-exposed specimens, the mechanically mediated signalling is, at best, impaired. Common medical diagnostic tests, such as EKG, EEG, as well as many blood chemistry analyses, are based on the mal-function of biochemical signalling processes. VAD patients typically present normal values for these tests. However, when echocardiography, brain MRI or histological studies are performed, where structural changes can be identified, all consistently show significant changes in VAD patients and ILFN-exposed animals. Frequency-specific effects are not yet known, valid dose-responses have been difficult to identify, and large-scale epidemiological studies are still lacking.

Keywords: Extra-cellular matrix; Actin; Tubulin; Collagen; Tensegrity

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1. Introduction

This review paper deals with the biological effects of infrasound (0–20 Hz) and low-frequency noise (ILFN) (20–500 Hz). For the past 60 years, there has been much controversy and acrimonious debate over whether or not acoustical phenomena can cause extra-auditory effects on living organisms (Alves-Pereira, 1999). At present, the only officially (and legally) recognized consequence of noise exposure is hearing loss, albeit noise-induced annoyance, sleep disturbances and hypertension have been gaining more recognition over the past several years.

The scientific understanding of non-auditory, noise-induced biological effects can only be achieved if several obstacles are overcome. These obstacles pertain to the way the scientific community, in general, and biological scientists, in particular, view noise pollution and cellular signalling: noise only causes hearing impairment and cellular signalling is accomplished only through biochemical pathways. These untenable positions are powerful (scientific) hindrances that have impeded valuable research efforts. There are other key obstacles related to the awareness and recognition of ILFN as an agent of disease, but these are associated with the political, financial and social features of our collective societies and are, therefore, beyond the scope of this report.

Much of the literature pertaining to this field of study has been produced by non-English-speaking authors. Although the majority possess an abstract in English, full translations of all these scientific papers (e.g., from Chinese, Russian, Slovenian, Japanese and Polish) have been difficult to obtain. Additionally, many of the early papers produced by this team (from 1980 through 1989) were published in Portuguese with abstracts in English. Hence, several scientific papers in this review are only referred to abstracts.

Herein will be demonstrated that excessive exposure to ILFN causes extra-auditory pathology, specifically, vibroacoustic disease (VAD), and that the physiological and biological basis for this disease can only be understood if the concept of mechanotransduction cellular signalling is taken into account.

2. Noise pollution

Historically, it is understandable that noise exposure has always been associated with hearing loss. According to the Epic of Gilgamesh, a Babylonian king who lived in 2700 BC, the Great Flood was brought to